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BIOLOGICAL EVALUATION
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EVALUATION OF MOUNTAIN PINE BEETLE ACTIVITY IN THE BEAVER PARK AREA OF THE BLACK HILLS NATIONAL FOREST

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ABSTRACT

Mountain pine beetle populations have been increasing in the Black Hills over the last 3 years. Over the past few years, aerial surveys have detected a large and expanding mountain pine beetle infestation in the Beaver Park area on the Northern Hills Ranger District. Ground surveys found 37 trees per acre killed on average over the last 3 years, with approximately 53% of these trees being currently infested. Also, brood sampling continues to indicate that beetle populations are still increasing in the area. Four years ago nearly 70% of the forested land in the Beaver Park area was classified in the moderate to high stand hazard categories. Stand hazard is being reduced as beetles have reduced much of the basal area. However, as beetle habitat is lost in areas such as Forbes and Beaver Gulches, the beetles are starting to move out into surrounding forest lands in the area. Places such as Vanocker Canyon, Park Creek, and Elk Creek Canyon are becoming heavily infested with mountain pine beetle.

Recommendations for dealing with the mountain pine beetle include: silvicultural treatments, sanitation/salvage harvesting, infested tree treatment and individual tree protection. Aggressive use of silvicultural techniques, both thinning and sanitation, are the recommended actions.

Beaver Park aerial view, July 2002

INTRODUCTION

Mountain pine beetle (*Dendroctonus ponderosae*) is the number one insect killer of pines throughout the western United States. The beetle is a native species to the West and attacks most pine species including ponderosa pine in the Black Hills.

The mountain pine beetle has one generation per year in the Black Hills. Adult flight occurs in July - August, when adults leave previously infested trees and attack uninfested, green trees. Attacking adults, chew through the bark and construct galleries along which eggs are laid. Larvae hatch from the eggs and begin feeding on the phloem of the tree in late summer to early fall. Larvae, pupae or new adults overwinter under the bark of the infested tree. In the spring, the beetle finishes its maturation process, producing the next generation of adults. The larvae kill trees by feeding on the inner bark or phloem and cutting off sugar flow from the needles to the roots. The introduction of blue stain fungus by the beetles causes clogging of the water conducting tissues in the tree, speeding up the trees death.

Populations of the mountain pine beetle are usually found at a low population level, killing and reproducing in stressed or weakened trees, including lightning struck and root diseased trees. In populations that are increasing to epidemic stages, healthy trees are attacked and killed along with stressed trees. In 1999, areas of Beaver Park had tree mortality ranging between 83 trees per acre to 1 tree per acre killed over a three-year span (Allen and McMillin 1999). Populations in Beaver Park have continued to increase over the past 2 years.

Mountain pine beetle has always been a part of the Black Hills forest ecosystem, with outbreaks occurring periodically. There have been 5 or 6 major outbreaks of mountain pine beetle in the Black Hills over the past 100 years, each lasting about 10-15 years. Outbreaks of the beetle can cause considerable changes in forested stands, including a reduction in average stand diameter and stand density (McCambridge et al. 1982). Tree mortality levels of 25% can be expected throughout the landscape surrounding outbreak areas and levels of up to 50% or more can occur in heavily attacked stands (McCambridge et al. 1982). Outbreaks can conflict with land management objectives: they reduce timber stocking levels, affect wildlife habitat, increase short term fire risks, and can negatively effect visual, old growth and recreation values (Samman and Logan 2000).

Stand hazard ratings give an indication of which stands are most likely to have initial beetle infestations. These ratings also give no indication of local beetle pressure. Once an outbreak has started, any stands containing suitable host material are at risk. However, hazard ratings can help to prioritize which stands should be treated to minimize beetle susceptibility.

Attempts to suppress outbreaks in progress are extremely costly and often overwhelmed. Prevention in select areas is possible, while stopping all beetle caused mortality is not. The best approach to reducing losses to the mountain pine beetle for the long-term is forest management to reduce stocking densities. Decreases in

stocking densities will lower the probability that beetle outbreaks will be initiated, but it is a continual process to keep stands in the low risk category. Generally stands are considered to be most susceptible when 75% of the stand is in the 7-13 inch diameter range and the stand density is over 120 feet of basal area per acre (Stevens et al. 1980, Schmid and Mata 1992). Recent work has shown that areas treated to 60 basal area can be expected to reach high hazard (120 basal area) again in about 25-50 years. Stands treated to 80 basal area can reach 120 basal area in 13-36 years, and stands treated to only 100 basal area will be back to 120 basal area in 9-16 years (Obedzinski et al. 1999). The timeframes of when a forest can increase in hazard level are relatively short, often shorter the time between treatments in a stand.

Generally, when beetle populations reach outbreak proportions, natural enemies, such as birds and predaceous or parasitic insects, are not numerous enough to have a noticeable effect on the outbreak. Natural enemies are more important in limiting mountain pine beetle populations that are at endemic levels (Bellows et al. 1998). Likewise, environmental factors cannot be counted on for lessening the outbreak. For example, temperatures of -10° F can kill beetles in October but temperatures of -25° are needed by February (Schmid et al. 1993). These temperatures need to be reached under the bark, in the phloem, as opposed to air temperatures. Beetles survive low temperatures by removing water from within their cells and replacing it with glycoproteins, which act as a type of anti-freeze (Bentz and Mullins 1999). This is a process known as cold hardening. Beetles have supercooling points, the temperature at which ice crystals start to form in body tissues, as low as -32° F in January (Bentz and Mullins 1999). Phloem temperatures become equal to air temperatures only when they persist for 24 hours or more (Schmid et al. 1993). Generally, phloem temperatures are found to be 5 to 10° F warmer than air temperature.

The focus of this evaluation is to examine the continuing beetle situation in the Beaver Park area of the Black Hills National Forest. The evaluation is based on aerial survey information, ground surveys, and brood sampling data. Potential pest management strategies and recommendations for management are presented.

METHODS

The current mountain pine beetle conditions for the Beaver Park were evaluated using aerial survey data, brood sampling, and ground transects to estimate beetle caused mortality. Stand hazard ratings for the Beaver Park area using the USDA Forest Service RIS database were reported in 1998 and were not repeated in this evaluation (Allen and McMillin 1998). It is assumed that with the extensive tree mortality that has occurred since then, the overall the number of stands in the high and moderate classes has decreased.

An aerial survey was conducted in August 2002. The approximate number of fading trees and their location was mapped in this survey. These surveys detect pines that have been killed in the last 1-2 years and whose crowns have faded. Currently infested trees, whose crowns have not faded, cannot be discerned from the air.

Brood sampling was carried out in November 2002 according to methods described by Knight (1960). A 6 x 6-inch piece of bark was removed from the north and south sides of currently infested trees. All live and dead mountain pine beetle brood in the pieces were counted. Twenty trees were sampled at each of 3 sites in the Beaver Park area. The numbers of brood found were totaled for each area. The cumulative number of brood is used in several regression equations to classify whether beetle populations are decreasing, increasing or static.

Transect lines were run throughout the Beaver Park area in October and November 2002. Transect lines ranged from ¾ to 1 mile in length and was 1 chain wide, covering an area of 2 acres per quarter mile of line. Recently killed trees were tallied along each transect line. Attacked trees were broken into three categories: new beetle hits (year 2002 green attacked trees), one-year-old hits (2001), and two-year-old hits (2000).

Eighteen transect lines were run, covering 21.75 miles throughout the Beaver Park area, for a total of 174 acres evaluated. On each line, variable radius prism (BAF 10) plots were measured every ¼ mile. Diameter at breast height (DBH) was taken for all in trees in each plot. These measurements were used to provide an estimate of basal area (BA), DBH, and trees per acre (TPA) along the transect lines.

RESULTS

During the mid-1990's, beetle mortality was light and scattered throughout the Black Hills. In 1997, there was a noticeable increase in mortality detected. The 1999 survey showed another sharp increase from 1998, with most of the heaviest mortality concentrated in a few areas, most notably the Beaver Park area. The aerial survey numbers from 1996 through 2002 in the Beaver Park area are listed below:

Year	Estimated # of Dead Trees
1996	210
1997	1650
1998	3800
1999	15000
2000	35000
2001	100800
2002	113650

Beetle populations are at epidemic proportions in this area of the Black Hills and tree mortality is very intense in a number of areas in and around Beaver Park.

Results from brood sampling are shown in Figures 1,2, and 3. These figures represent brood developing from attacks that occurred in August 2002. In all cases, the data classify mountain pine beetle populations as increasing in the Beaver Park area.

Slight decreases in this year's brood are expected before beetle flight occurs in the summer of 2002. Natural enemies and competition with woodborer larvae feeding on the same food resource can cause brood mortality. The amount of mortality caused by weather factors, for example cold temperatures, is expected to be negligible. Samples were taken in mid-November after low temperature extremes had occurred earlier in the fall and very little larval mortality was noted. Overall, it appears that any decrease in brood will be insignificant.

Table 1 lists the number of beetle-killed trees found on all transects for the 2002 ground survey in the Beaver Park area. Mortality from 2000, 2001, and green infested trees show that there is an average of 37 trees per acre killed throughout this area. A little over half of the attacked trees are currently infested, with the other half being one- and two-year-old hits. This value is similar, although slightly less, to the 46 trees per acre killed that was found last year (Allen & Long 2001).

Table 2 lists the number of attacks by transect line in the Beaver Park area, and corresponding average basal area and diameter of trees along that line. Much of the area in the central part of Beaver Park where the infestation initially started is now left with very little in the way of live trees in the overstory. It will likely be 80-100 years before there is anything resembling a mature pine forest in this area again. In addition, moderately large pockets of infested trees, up to 200-300 trees, can be found scattered

throughout the remaining area. Many of these areas, such as Vanocker Canyon, Kirk Hill and Elk Creek Canyon are outside of the Beaver Park roadless area proper, and are showing very heavy infestations at this point. Much of the pine overstory in the roadless area has been killed off, and the infestation is now spreading to other parts of the surrounding forest. The average tree diameter (DBH) per transect line ranged from 8.6 inches to 12.8 inches and the average basal area ranged from 98 to 188 square feet per acre. This combination of tree size and stand density provide suitable habitat for beetle infestation and are characterized as moderate to high beetle hazard. Additionally, having these conditions occur over such a large and contiguous area as in Beaver Park lends itself to the continuation of a large-scale beetle epidemic.

Predicting mountain pine beetle spread and cumulative mortality over the course of an outbreak is difficult. The amount of tree mortality from our transect lines is a conservative estimate in that only mortality that has occurred in the last three years was accounted for and the outbreak is by no means over. Based on the last three years, however, mortality on a transect lines ranged from 4-49% of the average trees per acre. The lower end of the range are in areas farthest away from the core infestation in the center of the Beaver Park Roadless area with the high end being in the center of Forbes Gulch, where beetle activity has been the most intense over the last three years. The final impacts will not be known until the epidemic subsides.

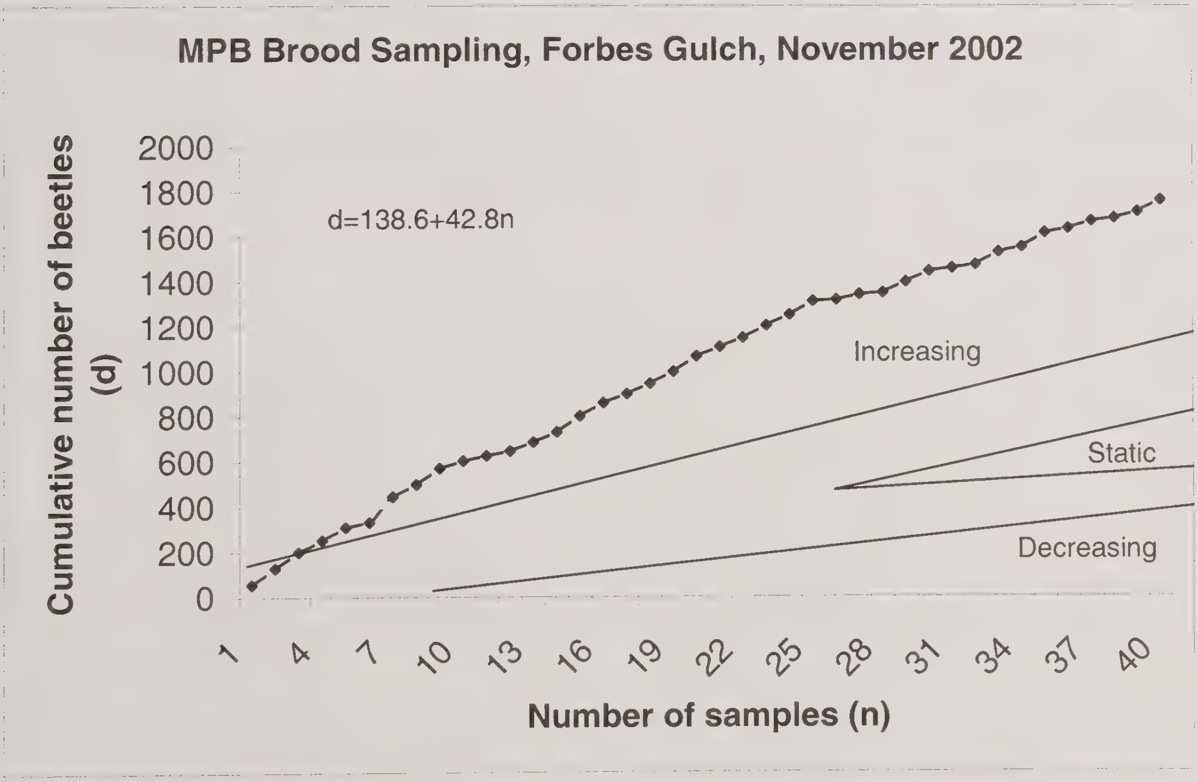

Figure 1. Sequential sampling of mountain pine beetle brood conducted in November, 2002 in Forbes Gulch.

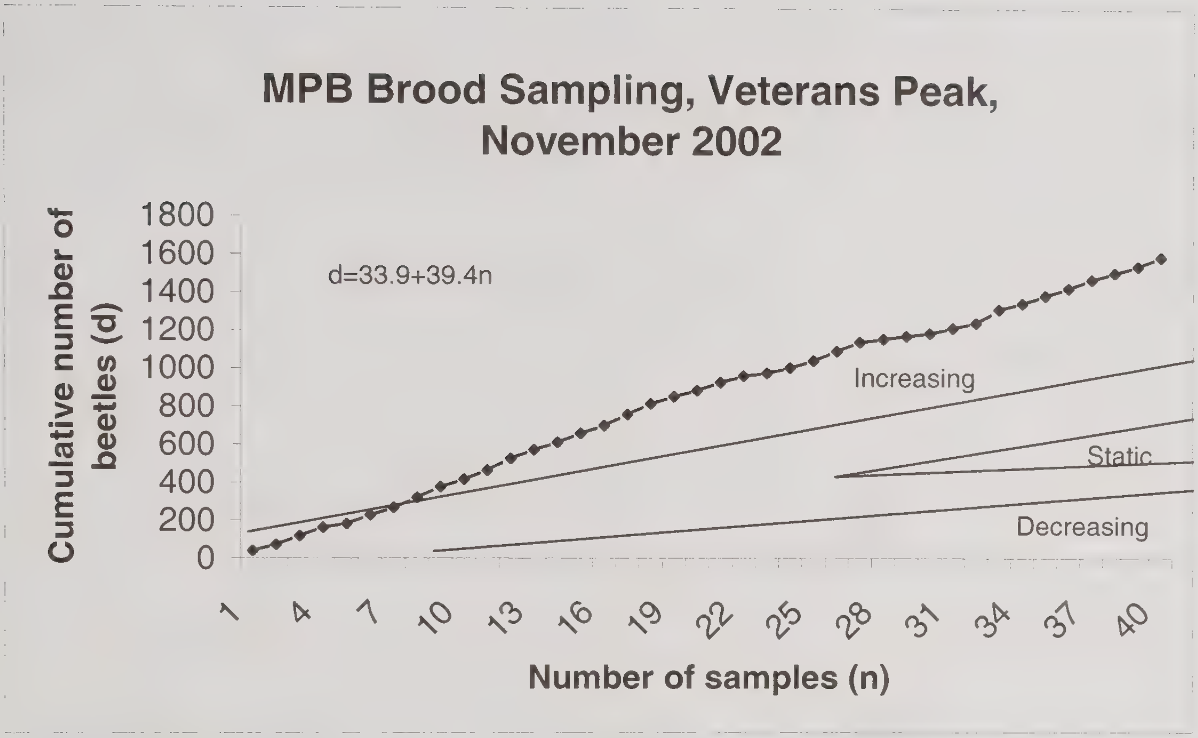

Figure 2. Sequential sampling of mountain pine beetle brood conducted in November, 2002 at Veterans Peak.

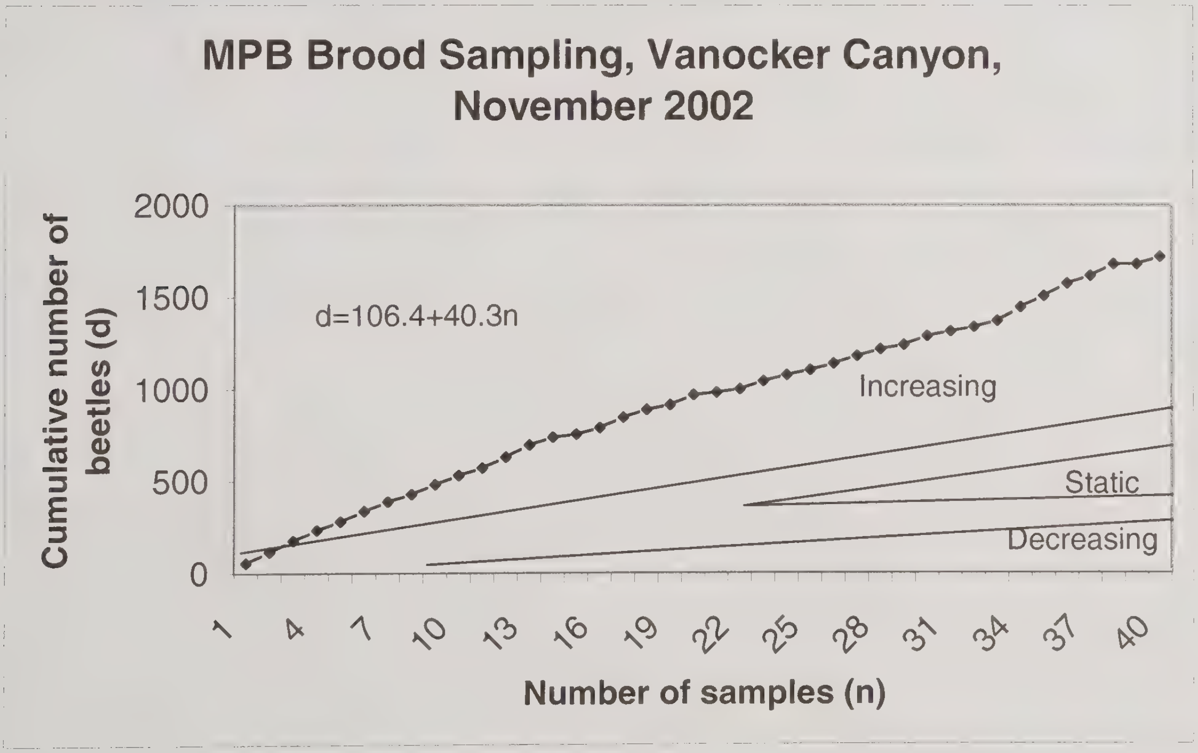

Figure 3. sequential sampling of mountain pine beetle brood conducted in November, 2002 at Vanocker Canyon.

Table 1. Number of mountain pine beetle attacked trees along 21.75 miles (174 acres) of transect lines in the Beaver Park Area, Northern Hills Ranger District, and the ratio of attack frequency between years.

Year	Total Trees Attacked	Attacked Trees per Acre
2000 Dead	739	4.2
2001 Dead	2330	13.4
Green Infested	3424	19.7
All Attacks 2000-2002	6493	37.3

RATIO OF ATTACK FREQUENCY BETWEEN YEARS

2000:2001	1:3.1
2001:2002	1:1.5
2000:2002	1:4.6

Table 2. Number of trees attacked per acre by mountain pine beetle along with average tree diameter, basal area, and trees per acre by transect line in the Beaver Park Area

Transect	**CY**	**2001**	**2000**	**Total**	**BA**	**DBH**	**QMD**	**TPA**	**TPA Killed**	**%TPA Killed**
1	138	64	45	247	132	11.6	11.9	206	31	15%
2	845	702	140	1687	129	9.6	9.9	246	121	49%
3	207	115	68	390	188	10.9	11.1	284	24	9%
4	303	251	48	602	135	11.5	11.9	185	28	20%
5	525	106	10	641	137	10.1	10.3	249	80	32%
6	68	84	37	189	116	9.6	10.0	231	19	8%
7	72	160	54	286	130	12.8	13.2	149	24	16%
8	68	16	5	89	138	9.9	10.1	173	9	5%
9	293	76	71	440	143	9.5	9.7	277	73	27%
10	212	61	33	306	117	8.6	8.9	274	38	14%
11	131	39	14	184	112	10.4	10.6	196	23	12%
12	50	63	4	117	147	10.9	11.2	267	12	4%
13	43	35	10	88	98	12.7	13.0	109	11	10%
14	91	152	35	278	102	10.1	10.3	191	35	18%
15	95	179	8	282	167	11.0	11.5	244	47	19%
16	69	80	52	201	136	10.7	10.9	226	20	9%
17	128	125	79	332	148	10.4	10.6	255	33	13%
18	86	22	26	134	133	11.7	11.9	184	22	12%
SUM	**3424**	**2330**	**739**	**6493**						
AVERAGE					**134**	**10.7**	**10.9**	**219**	**37**	**16%**

Abbreviations: CY-current year attacks, 2001-trees attacked in 2001, 2000-trees attacked in 2000, BA-basal area, DBH-diameter at breast height, QMD-quadratic mean diameter, TPA-trees per acre.

CONCLUSIONS

The number of trees killed per acre found in Beaver Park is approaching totals that are above and beyond those reported for previous outbreaks in the Black Hills. The number of trees per acre attacked in one year has been as high as 26.8 on the Spearfish District in the beetle epidemic of the 1970's (Creasap and Minnemeyer 1976) and 61.4 in the Bear Mountain/Whitehouse Gulch area in the early 1990's (Pasek and Schaupp 1992). The number of killed trees in certain areas within Beaver Park area is already above these reports, with highs over 100 trees per acre killed. Entire hillsides are now completely devoid of large trees. Year-to-year attack ratios of 1:2 or 1:3 are fairly common in population buildups. The overall attack ratio from 2001 to 2002 was 1:1.5; however, there were a number of places where that ratio was 1:4 or 1:5.

Many of the places that have the largest expanding populations are now outside of the Forbes Gulch area. Stand conditions in areas that have not been already affected by beetles remain conducive to sustaining high levels of beetle caused mortality. The areas that are starting to decline in beetle infestation are those where most or all of the forest has already been killed.

All infested trees that were examined had live brood in them, mostly larvae. A general observation from the ground surveys was that there was some woodpecker activity, though it was very light and scattered, throughout the area. Natural enemy activity seems light to moderate overall. Although woodpeckers typically forage for woodborer larvae that follow mountain pine beetle, they also eat some mountain pine beetle larvae. At this point it is unknown what percentage of the beetles will overwinter successfully; however, with the high number of new attacks there will be plenty of beetles to continue to fuel this outbreak in 2003.

Mountain pine beetle has reached and sustained outbreak proportions in the Beaver Park area. Currently, there are extensive pockets of mortality and the population is still building. Dramatic changes on the landscape have already occurred and additional changes can be expected in the next few years as mortality continues to increase. Any of the areas surrounding Beaver Park that contain suitable host material are also at risk to sustaining losses over the next few years. In ponderosa pine in the Black Hills, it was estimated that around 80% of susceptible trees had been killed in portions of the Bear Mountain area in the late 1980's and early 1990's (Pasek and Schaupp 1992). Again, stand conditions in this area were similar to those currently found in Beaver Park. McCambridge and others (1983) found that greater than 50% of heavily attacked stands of ponderosa pine were killed in Colorado. The final totals for mortality in the Beaver Park should equal or surpass the 50% level in moderate or high risk stands, and more than likely will approach the 80% level. There are already stands where the level of mortality has reached 100%. Beaver Park has been under significant attack from mountain pine beetle in large part due to the vast quantity of suitable beetle habitat in this area. When lagre areas are regenerated all at once and then left unmanaged, they create areas of unbroken forest that is highly susceptible to mountain pine beetle. The question now becomes how large of a landscape will be affected to this level.

PEST MANAGEMENT STRATEGIES

There are a number of actions that can be used to reduce the impacts of mountain pine beetle. These actions fall into two categories: direct action against the beetles themselves or indirect action that address the general stand conditions. Direct action deals with the symptoms, too many beetles in one place at one time, and is aimed at directly reducing the number of beetles present. Indirect action focuses on the cause of the problem, which relates to optimal stand conditions for beetle buildup and outbreak.

Strategy 1: Silvicultural Treatments. These are forest management actions that increase tree vigor and reduce stand susceptibility to beetle attack through reducing basal area or controlling other stand conditions. They are preventative treatments that should be completed prior to stands experiencing beetle outbreaks. In the Black Hills, stands that are less than 80 square feet of basal area per acre with average stand diameters below 7 inches are at the lowest risk. When treating stands care must be taken to avoid leaving pockets of dense trees in an otherwise thinned stand.

Strategy 2: Sanitation/Salvage Harvest. Sanitation harvesting involves the removal of green trees that have live beetle brood in them. These green trees are already dead, however, the foliage will not change color until the following summer. Trees removed in a sanitation harvest are treated; either moved to at least one mile from the nearest live host type or processed at the mill, prior to beetle emergence. Salvage harvest involves the removal of beetle-killed trees that no longer have live beetles in them. These trees have already changed color; their needles are either red or gone. Salvage does nothing to reduce the beetle population in the area, but can help recoup some timber value.

Another type of sanitation treatment involves treating infested trees without removal. Trees can be cut and individually treated trees prior to beetle emergence. The action should kill most or all of the beetles within the cut trees. Examples of treatments include: cut and burn on site, cut and bury at least 6 inches on site, cut and chip, cut and debark. This type of sanitation is very time and labor intensive.

Strategy 3: Protection of High Value Trees. Prior to beetle emergence in the summer, the stems of high value uninfested trees are treated with a registered insecticide. This relatively expensive treatment only works as a preventative; there is no chemical treatment available for trees that are already infested.

RECOMMENDATION

Strategy 1, silvicultural treatments, should be the most heavily considered alternative for managing mountain pine beetle. Sound forest management, such as maintaining a diversity of age classes, diversity of species where possible and reducing basal area where it fits management objectives is the only way to minimize extensive losses to the beetle over long periods of time. Thinning of stands in the Beaver Park area should proceed prior to beetle infestations, where possible. The more forest that can be preventatively treated by thinning, the better. This will help to limit the spread of beetles out from Beaver Park. Extensive thinning will help create a mosaic of susceptibility for the future. Allowing the beetles to completely kill the overstory in entire areas will result in those areas all regenerating at the same time, once again creating a landscape with little diversity.

Traditional sanitation treatments of beetle infested trees should also be done where it is possible. Removal of infested trees is not going to completely stop the outbreak, but could be helpful in reducing beetle populations at the local level and limiting the further

spread of the outbreak. Any sanitation efforts aimed at this years brood would have to be finished prior to July 2003. Populations are already spreading to adjacent areas at this point and will continue to expand and cause mortality in surrounding areas. These areas where the infestation is moving into now should be a top priority for treatment.

Use of single tree sanitation, where the trees are not removed, could be considered, especially in high profile areas. These treatments can be used to kill overwintering beetles, thereby reducing the emerging beetle population to some extent. This alternative is not appropriate over the entire Beaver Park area, but may be useful in localized spots.

The use of protective sprays should be used only in very high value areas.

The treatments beginning in the surrounding sale areas are a good start. Where possible, these treatments should be as aggressive as possible to try and start to knock down the beetle outbreak and reduce susceptibility. Beetle populations are continuing to grow and mortality will continue to increase. The forest in the core of the Beaver Park area has already been significantly affected and changed, and there are surrounding areas that are becoming significantly impacted. At this point, there is no foreseen end of the outbreak in the Beaver Park area.

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